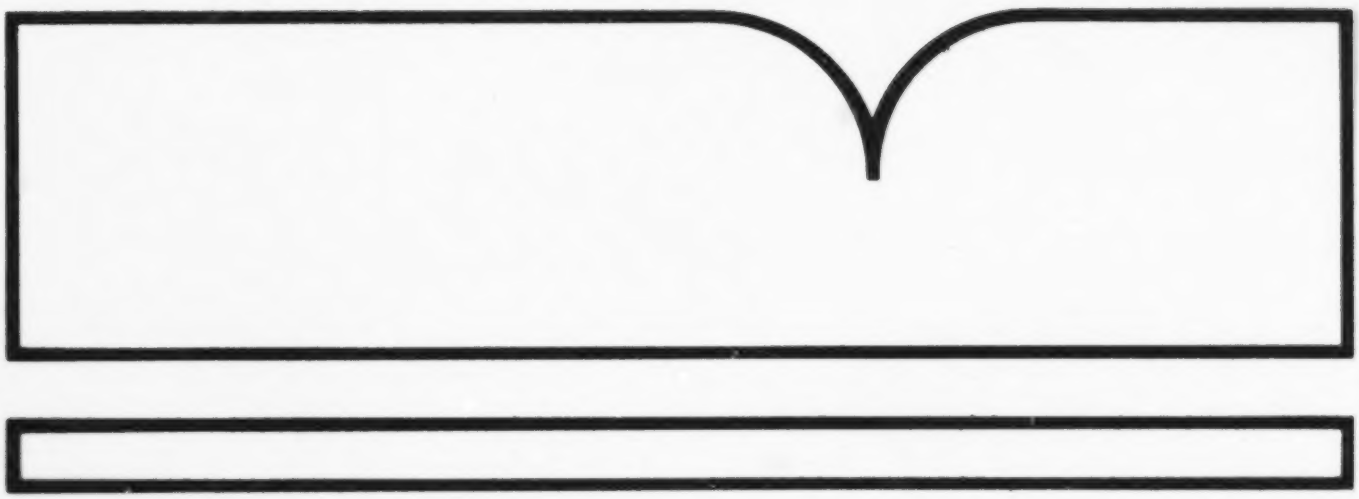
PB89-192587

Pesticides in Ground Water Data Base: 1988 Interim Report

(U.S.) Environmental Protection Agency, Washington, DC

Dec 88



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Abstract: One of EPA's priorities is to determine the extent of pesticides occurring in the nation's ground water. While many individual, localized ground-water monitoring studies have been conducted across the country, there has been no comprehensive compilation of these results. In response to this, the EPA's Office of Pesticide Programs has developed the Pesticides in Ground Water Data Base. The data base contains information derived from monitoring studies conducted by pesticide registrants, universities, and government agencies. The data base identifies the pesticides that have been looked for in ground water, the areas that have been monitored, and the pesticides that have been detected. The data base was developed in the first quarter of 1988, and at the same time, a public docket was established so interested parties could have access to the source information. Following the development of the data base, the EPA has been conducting a program to assess the validity of the information it contains. At this time, the authors believe they have gathered sufficient information to provide the public with an interim report on the national status of pesticide residues in ground water.

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PESTICIDES IN GROUND WATER DATA BASE
1988 INTERIM REPORT

United States Environmental Protection Agency
Office of Pesticide Programs
Environmental Fate & Effects Division
Environmental Fate & Ground Water Branch

December 1988

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1.0 EXECUTIVE SUMMARY

Background

One of EPA's priorities is to determine the extent of pesticides occurring in the nation's ground water. While many individual, localized ground-water monitoring studies have been conducted across the country, there has been no comprehensive compilation of these results. In response to this, the U.S. Environmental Protection Agency, Office of Pesticide Programs, has developed the Pesticides in Ground Water Data Base. The data base contains information derived from monitoring studies conducted by pesticide registrants, universities, and government agencies. The data base identifies the pesticides that have been looked for in ground water, the areas that have been monitored, and the pesticides that have been detected. The data base was developed in the first quarter of 1988, and at the same time, a public docket was established so interested parties could have access to the source information.

Following the development of the data base, the Agency has been conducting a program to assess the validity of the information it contains. The program involves contacting the author or director of each monitoring study and requesting that they review and confirm our interpretation of the information. The authors are being requested to identify the source of contamination for each reported detection and document the laboratory analytical methodology used to quantify the results. At this time, we believe we have gathered sufficient information to provide the public with an interim report on the national status of pesticide residues in ground water.

Results

To incorporate the scientific rigor and quality assurance we have instilled in this program, the results are presented in several categories based on the confidence we have in the information. Many of the reported detections have not been confirmed, and some of the contamination is from unknown sources. However, we consider all of this information important, and have segregated the data accordingly.

We have tried to distinguish point-source contamination from pesticide occurrence in ground water resulting from leaching through the soil profile following normal agricultural applications. In general, point-source pollution refers to water pollution caused by discharges into receiving waters from the end of pipelines, localized spills, or other identifiable "points". We have broadened this definition in presenting our results to include documented misuse (i.e., use on a crop or in areas for which it is not registered) as well as conventional point sources such as spills or well contamination by direct channelling.

Each entry in the data base has been assigned a rating reflecting the quality or confidence in the results. Studies that have been conducted under sound documented protocols where the results have been confirmed by acceptable analytical techniques are assigned the highest rating of confirmation. Lower ratings are assigned to studies in which the protocols are less poorly documented and analytical confirmations are less reliable.

A total of six categories have been designed to present the results, but three categories are given particular attention. Category 2 includes all information collected to date - excluding data known to be of poor quality and data that is from known point-source contamination. Category 5 includes information that has been derived from scientifically confirmed studies where the contamination is attributed solely to normal agricultural use. Category 6 includes confirmed information attributed solely to known point sources or documented misuse. The results from these categories are given below:

Category	Number of Pesticides Detected	Number of States with Detections
2. All data excluding data of known poor quality and known point sources or misuse	74	38
5. Confirmed data attributed to normal agricultural use	46	26
6. Confirmed data attributed to point sources or misuse	32	12

The results from categories 2 and 5 are depicted on a map of the United States in Figure 1-1. Table 1-1 presents a summary of pesticides that have confirmed detections in ground water attributed to normal agricultural use (category 5) and point sources or documented misuse (category 6). This table also illustrates whether the pesticide has been included as an analyte in the National Pesticide Survey, the number of states in which each pesticide has been detected, the range of concentrations detected, and the proposed EPA Health Advisory for the pesticide.

Because many of the studies in category 2 have not yet been confirmed and the unknown sources may be the result of normal agricultural practices, we believe that the precise representation of the national status of pesticide residues in ground water as a result of normal agricultural application is greater than category 5. It is important to note, however, that one or two detections of a pesticide at trace levels, does not indicate a problem in itself. However, a particular pesticide detected at numerous locations at concentrations equal to or greater than Health Advisory levels is reason for concern. For this reason, it is critical to look at both the frequency of detections and their concentrations, and how those concentrations compare to established and proposed health numbers for a specific pesticide before drawing conclusions on the severity of the problem.

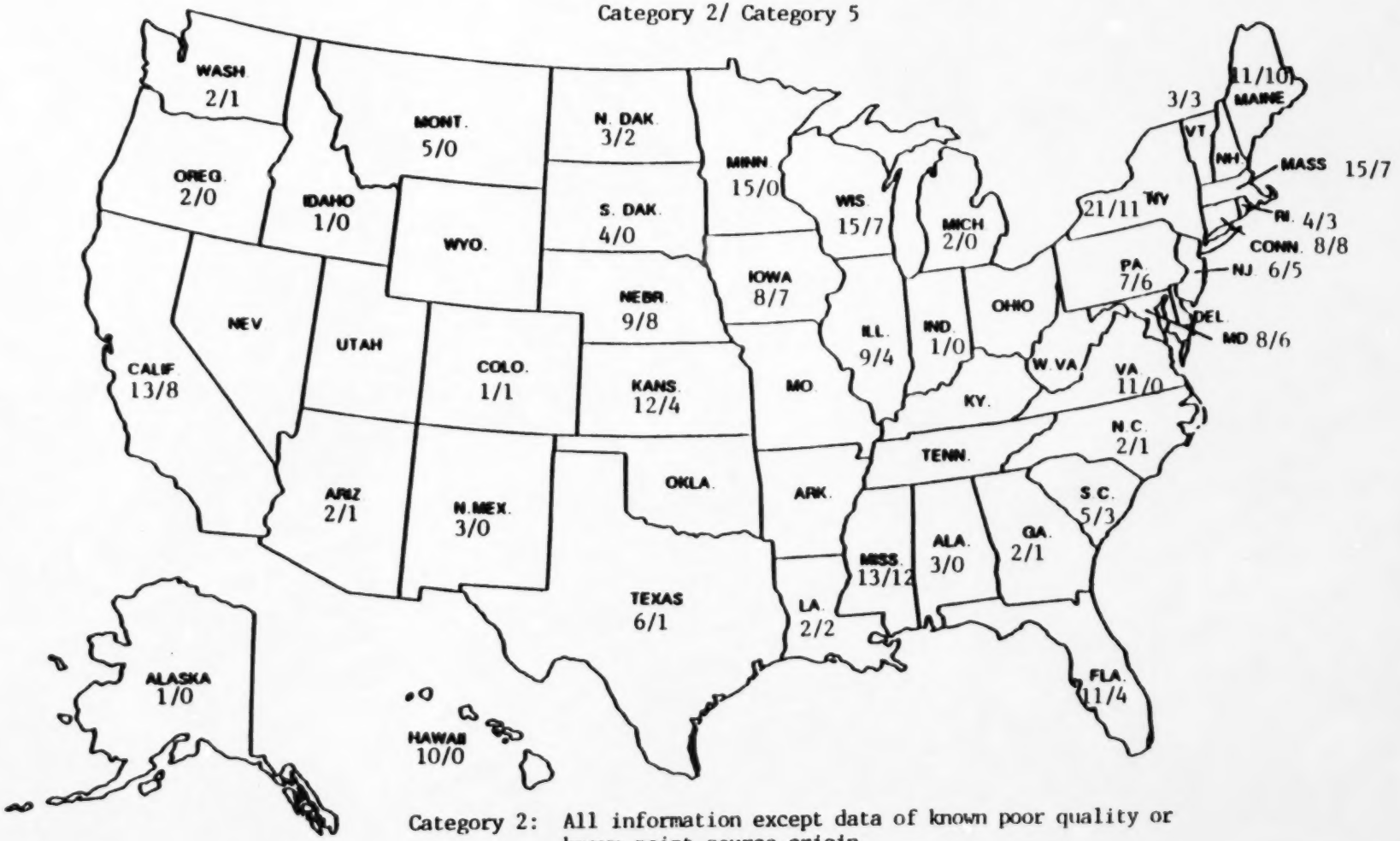
Caveats on Using the Data Base

There are dangers in trying to use Figure 1-1 to indicate the statistical significance of the problem on a national level. Many of the studies were only designed to sample vulnerable ground water or to investigate suspected problems, while other studies were designed to be statistically unbiased. It is important to note that the studies have not been limited to drinking water supplies and some studies have sampled many types of wells including wells used only for observation or irrigation. Many of the studies have concentrated on shallow ground water which may not be representative of the drinking water sources of the area. As such, the results cannot be used to estimate human exposure to pesticides in drinking water.

Pinpointing the source of pesticide contamination is perhaps the most

FIGURE 1-1

Numbers of Pesticides Found in Ground Water As a Result of Agricultural Practice



Category 2: All information except data of known poor quality or known point source origin.

Category 5: Only confirmed data attributed to agricultural uses.

TABLE 1-1
Confirmed Detections of Pesticides in Ground Water

Chemical Name	Cancelled or Severely Restricted	Analyte in NPS **	Health Advisory Level *** (ppb)	Normal Use			Point Source
				States with Detects	Maximum Concen. (ppb)	Median Concen.**** (ppb)	States with Detects
1,2-D	Y	Y	0.0013 *	4	550.00	4.50	
1,3-D		Y	0.20 *	1	270.00	123.00	1
2,4,5-T	Y	Y	21				1
2,4-D		Y	70	2	49.50	1.40	1
2,4-DB		Y					1
Alachlor		Y	1.5 *	12	113.00	0.90	7
Aldicarb		Y	10	7	315.00	9.00	
Aldrin		Y		2	0.10	0.10	
Arsenic	Y			1	N/A	N/A	1
Atraton		Y		1	0.10	0.10	
Atrazine		Y	3.0	13	40.00	0.50	7
BHC	Y	Y		1	4.30	2.70	1
Bromacil		Y	80	2	22.00	9.00	1
Carbofuran		Y	36	3	176.00	5.30	
Chlordane	Y	Y	0.03 *	1	1.80	1.70	1
Chlorothalonil		Y	1.5 *	2	12.60	0.02	1
Cyanazine		Y	9.0	6	7.00	0.40	1
DBCP	Y	Y	0.02 *	2	0.02	0.01	
DDT	Y	Y		3	402.00	1.70	1
Dacthal		Y	3500	1	1039.00	109.00	
Diazinon		Y	0.63	1	478.00	162.00	1
Dicamba		Y	9.0	2	1.10	0.60	1
Dieldrin	Y	Y	0.00219 *	2	0.02	0.02	1
Dinoseb	Y	Y	7.0	3	36.70	0.70	
Diuron		Y	14	1	N/A	N/A	
EDB	Y	Y	0.0005 *	6	14.00	0.90	1
Endosulfan		Y		1	0.40	0.30	1
Endrin	Y	Y	0.032				1
Ethoprop		Y		1	12.60	N/A	
Fonofos			14	2	0.90	0.10	
Heptachlor	Y	Y	0.076 *				1
Hexazinone		Y	210	1	9.00	8.00	
Lindane	Y	Y	0.026 *	3	47.00	0.10	1
Linuron		Y		1	2.70	1.90	
Malathion				1	53.00	41.50	1
Methamidophos				1	10.50	4.80	
Methomyl		Y	175	1	9.00	N/A	
Methyl parathion		Y	2.0	1	256.00	88.40	1
Metolachlor		Y	10	5	32.30	0.40	5
Metribuzin		Y	175	4	6.80	0.60	1
Oxamyl		Y	175	3	395.00	4.30	

TABLE 1-1
Confirmed Detections of Pesticides in Ground Water
(continued)

Chemical Name	Cancelled or Severely Restricted	Analyte in NPS **	Health Advisory Level *** (ppb)	Normal Use			Point Source
				States with Detects	Maximum Concen. (ppb)	Median Concen.**** (ppb)	States with Detects
PCNB							1
PCP		Y	220				1
Parathion				1	0.04	0.03	
Picloram		Y	490	3	49.00	1.40	1
Prometon		Y	100	1	29.60	16.60	
Propazine		Y	14	2	0.20	0.20	1
Silvex	Y	Y	52				1
Simazine		Y	35	7	9.10	0.30	
Sulprofos				1	1.40	1.40	
TDE	Y	Y	0.031	1	6.20	4.80	
Toxaphene	Y			1	4910.00	3205.00	
Triallate							1
Trifluralin		Y	2.0	4	2.20	0.40	1

* Lifetime exposure levels based on a 10-6 risk of causing cancer.

** National Pesticide Survey

*** Proposed Lifetime Health Advisory Level

**** Median of the concentration of positive detections for all confirmed studies. If a particular chemical does not list multiple studies, then the single study average is given. If the data base reports a single positive well, than the average concentration reported for that well is given.

difficult parameter to confirm in the data base. Contamination can result from causes other than leaching through the soil profile following normal field applications. These causes include: improper pesticide disposal, accidental spills, rinsate from equipment maintenance, human error in mixing, intentional excess applications, back siphoning into a well during chemigation, or direct channelling of pesticides through poorly constructed or damaged wells. It is difficult to conclude with confidence that ground-water contamination is the result of leaching from normal agricultural use, unless the above factors can be excluded.

Use of the Data Base by EPA

The data base will be used by the Agency to supplement the regulatory process for pesticides. It is being used to target pesticides that are contaminating ground water and establish priority candidates for regulation to mitigate such problems. The data base is being used to help identify the migration pathways and environmental factors associated with contamination which are the first steps in developing mitigation strategies. It will also be used to highlight vulnerable areas for which reduced applications or other restrictions may be warranted, and to depict data gaps where additional monitoring should be conducted. In addition, the data base can be used in support of the reregistration of a pesticide for which ground-water contamination has not been shown to be a problem. The importance given to the data base in these functions will increase as the data base evolves.

With over 50 percent of the nation's population relying on ground water for their drinking water source, we cannot underestimate the seriousness of pesticides occurring in ground water. To address this problem, the Agency has many additional ongoing programs. EPA has developed an Agricultural Chemicals in Ground Water Strategy to delineate the appropriate federal and state roles and minimize the risk for future ground-water contamination. In addition, the National Pesticide Survey is being conducted to sample drinking water wells throughout the country to statistically assess the occurrence and levels of pesticides in drinking water wells. This type of statistically designed study is more appropriate for assessing human exposure to pesticides in drinking water than the Pesticides in Ground Water Data Base. As part of the National

Pesticide Survey, Health Advisory levels have been developed for 62 pesticides. The Agency has also developed a ground-water training module to educate certified applicators about preventing ground-water contamination. Ground-water monitoring studies are being required of registrants for the initial registration of chemicals and the reregistration of existing pesticides whose physicochemical properties indicate that they may persist in the environment and are likely to leach to ground water. For some pesticides, these programs have resulted in cancellations or voluntary withdrawals, the denial of new registrations and reregistrations, label statements to restrict application rates, restrictions on use in vulnerable areas, designation as a restricted-use pesticide, or Special Reviews (e.g., aldicarb).

2.0 INTRODUCTION

2.1 Background

Prior to the late 1970's, ground-water contamination from field-applied pesticides was almost entirely unexpected - primarily because soils were thought to behave as natural filters, and pesticides were assumed to degrade or volatilize rapidly. The discovery of aldicarb in 96 wells on Long Island (in 1979) and DBCP in over 2000 wells in California (from 1979-1982) focused attention on pesticides used in agriculture as potential ground-water contaminants. By the early 1980's, several incidents of ground-water contamination resulting from the field application of pesticides had been confirmed. Since then, increasing numbers of pesticides have been detected in ground water in an increasing number of states (Cohen, et. al, 1984; Cohen, et. al, 1986; and Holden, 1986). In 1987, the U.S. Environmental Protection Agency documented 19 pesticides occurring in ground water from 24 states attributed to agricultural practices (EPA/OPTS, 1987).

2.2 Pesticides in Ground Water Data Base

Many localized, individual ground-water monitoring studies for pesticides have since been conducted across the country; however, there has been no comprehensive compilation of these results to assess the nature and scope of pesticide residues in ground water. In response to this, the Environmental Protection Agency, Office of Pesticide Programs, Environmental Fate & Effects Division has developed the Pesticides in Ground Water Data Base. The data base contains the results of monitoring studies conducted by federal and state agencies, chemical manufacturers, and universities. These results have been obtained from published literature and through direct correspondence to the Agency. The data base identifies the pesticides that have been looked for in ground water, the areas that have been monitored, and the pesticides that have been detected. It has not been the intent of the data base to maintain a record of every sample that has been collected and analyzed for pesticide residues. The data base represents summary results (e.g., number of wells sampled, number of positive wells found, and the ranges of concentrations) for

monitoring studies that have been conducted. To the extent possible, these results are itemized down to the county level and by origin of contamination (e.g., point source vs. leaching due to agricultural application). The data base was developed in the first quarter of 1988, and at the same time, a public docket, containing the original source of information for every entry in the data base, was established so interested parties could have access to the information. The following contact is given for additional information on the public docket:

United States Environmental Protection Agency
Office of Pesticides Program
Field Operations Division (TS-787C)
Public Docket & Freedom of Information Section
401 M Street, S.W.
Washington, DC 20460

Telephone: (703) 557-2805

The data has been obtained from many different studies that have not been conducted under a single standardized protocol. In order to minimize the misuse of poor quality data, the Agency has been conducting a program to assess the validity of the information in the data base. This program includes contacting the author or director of each monitoring study to request that they confirm our interpretation of their data, fill in missing information, and document the laboratory analytical methodology used to quantify the results.

A status report on pesticides in the nation's ground water is presented in the following sections. Section 3 presents assessments made from the data base. Included in Section 3 are summaries of the number of pesticides found in ground water and the number of states in which they have been detected. Additional results are presented for data that has been confirmed to date. Conclusions are given in Section 4 along with appropriate caveats for using the data. This section discusses how the Agency will be using this data in the future. References are contained in Section 5, and background information on both the data base structure and the data confirmation program are given in Appendix A. Data listings and other summary tables are included in Appendices B through F.

3.0 ASSESSMENTS WITH THE DATA BASE

3.1 Assessment Categories

Over 70 different pesticides have been reported in ground water in nearly 40 states; however, many of the reported detections have not been confirmed, and some of the contamination has resulted from unknown sources. The results are presented in six categories in order to differentiate normal agricultural use from point-source contamination and to reflect the confidence we have in the information. The results range from assessments based on all data in the data base to assessments that only include data that has been confirmed and attributed to a single source of contamination. The categories are presented and defined in Table 3-1.

Three of the categories are given particular attention. Category 2 includes all information collected to date, except data known to be of poor quality or data where the contamination has been documented as being due to point sources or some mechanism other than field leaching due to agricultural application. Category 5 includes information that has been derived from scientifically confirmed studies where the origin of contamination is attributed solely to normal agricultural use. Category 6 includes information confirmed from studies where the contamination is attributed solely to known point sources, direct well channelling, or uses in a manner for which they have not been registered (i.e., misuse).

3.2 Overall Results

An inventory of pesticides that have been detected in ground water from these six categories is presented in Table 3-2. The table indicates the number of pesticides that have been found in ground water and the number of states in which pesticides have been found. These summaries are expanded in Tables 3-3 and 3-4. Table 3-3 illustrates the number of pesticides that have been reported in ground water for each state. Table 3-4 presents the number of states in which each pesticide has been detected. Table 3-4 also footnotes which of the pesticides have been cancelled or have had their use severely

TABLE 3-1
Categories Used for Assessments

CATEGORY	DESCRIPTION	CODE	INCLUDES	EXCLUDES
1	All data	Origin: Confirm:	All 0-5	None None
2	All data except suspected point sources or known poor quality.	Origin: Confirm:	NFU,SFU,N/A 0-3	PS,SPS,DC,SDC 4-5
3	Suspected field use data excluding known poor quality.	Origin: Confirm:	NFU,SFU 0-3	PS,SPS,DC,SDC,N/A 4-5
4	Confirmed, quality data of unknown or suspected field use origin.	Origin: Confirm:	NFU,SFU,N/A 1,2	PS,SPS,DC,SDC 0,3-5
5	Confirmed, quality data of known or suspected field use origin.	Origin: Confirm:	NFU,SFU 1,2	PS,SPS,DC,SDC,N/A 0,3-5
6	Confirmed, quality data of known or suspected point source origin.	Origin: Confirm:	PS,SPS,DC,SDC 1,2	NFU,SFU,N/A 0,3-5

Origin of Contamination Codes

NFU Known normal field use
SFU Suspected normal field use
PS Known point source
SPS Suspected point source
DC Direct channeling
SDC Suspected direct channeling
N/A Unknown origin

Confirmation Rating

1 - 5 in which "1" is very confident, subsequently "5" is poor quality data.
A code of "0" indicates that the confirmation has not been completed.

TABLE 3-2
Current National Assessments of Pesticides in Ground Water

Category	Description	No. of Pesticides Detected	No. of States with Detected Pesticides
1	All data	77	39
2	All data except suspected point sources or known poor quality.	74	38
3	Suspected field use data excluding known poor quality.	65	36
4	Confirmed, quality data of unknown or suspected field use origin.	52	27
5	Confirmed, quality data of known or suspected field use origin.	46	26
6	Confirmed, quality data of known or suspected point source origin.	32	12

TABLE 3-3
Number of Pesticides Detected in Ground Water in each State

STATE	CATEGORIES					
	1	2	3	4	5	6
Alaska	1	1	1	0	0	0
Alabama	3	3	3	0	0	0
Arkansas	3	0	0	0	0	3
Arizona	3	2	2	1	1	0
California	13	13	13	≥8	8	5
Colorado	1	1	1	1	1	0
Connecticut	8	8	8	8	8	0
Florida	14	11	11	4	4	1
Georgia	2	2	2	1	1	0
Hawaii	10	10	3	0	0	0
Iowa	13	8	7	7	7	0
Idaho	15	1	1	0	0	14
Illinois	17	9	9	4	4	0
Indiana	1	1	0	0	0	0
Kansas	14	12	4	12	4	7
Louisiana	2	2	2	2	2	0
Massachusetts	15	15	15	7	7	0
Maryland	8	8	8	6	6	0
Maine	12	11	10	11	10	0
Michigan	2	2	2	0	0	0
Minnesota	15	15	0	15	0	0
Mississippi	13	13	12	13	12	0
Montana	5	5	5	0	0	0
North Carolina	3	2	1	1	1	0
North Dakota	4	3	3	2	2	2
Nebraska	9	9	9	8	8	2
New Jersey	6	6	6	5	5	0
New Mexico	3	3	3	0	0	0
New York	24	21	11	11	11	4
Oregon	2	2	2	0	0	0
Pennsylvania	7	7	7	6	6	2
Rhode Island	4	4	3	3	3	0
South Carolina	5	5	4	4	3	0
South Dakota	4	4	4	0	0	0
Texas	9	6	4	2	1	3
Virginia	12	11	11	0	0	0
Vermont	4	3	3	3	3	2
Washington	2	2	2	1	1	1
Wisconsin	18	15	10	7	7	0

TABLE 3-4
Number of States in which each Pesticide has been Detected

CHEMICAL	CATEGORY 1	2	3	4	5	6
1,2-D [1,3]	6	6	5	4	4	0
1,3-D [2]	3	2	1	1	1	1
2,4,5-T [3]	4	3	1	2	0	1
2,4-D	13	10	7	4	2	1
2,4-DB	1	0	0	0	0	1
Alachlor [2]	19	18	15	13	12	7
Aldicarb [1]	22	22	21	8	7	0
Aldrin	5	4	3	2	2	0
Ametryn	1	1	0	0	0	0
Arsenic [3]	1	1	1	1	1	1
Atraton	1	1	1	1	1	0
Atrazine [1]	22	19	17	15	13	6
Azinphos-methyl	1	1	1	0	0	0
BHC [3]	3	2	2	1	1	1
Benomyl	1	1	1	0	0	0
Bromacil [1]	3	3	2	3	2	1
Butylate	1	1	0	0	0	0
Carbaryl	3	2	0	0	0	0
Carbofuran	7	6	6	3	3	0
Chloramben	1	1	0	0	0	0
Chlordane [3]	6	3	2	2	1	1
Chlorothalonil [2]	4	3	3	2	2	1
Chlorpyrifos	2	1	1	0	0	0
Cryolite	1	1	0	0	0	0
Cyanazine	10	8	6	7	6	1
DBCP [1,3]	6	5	3	3	2	0
DDT [3]	7	5	5	3	3	1
Dacthal	4	4	3	1	1	0
Diazinon [2]	3	1	1	1	1	1
Dicamba	9	6	4	4	2	1
Dieldrin [3]	7	5	4	3	2	1
Dimethoate	1	1	1	0	0	0
Dinoseb [3]	4	4	4	3	3	0
Disulfoton	1	1	1	0	0	0
Diuron [1]	2	2	2	1	1	0
EDB [1,3]	10	8	7	6	6	1
EPTC	2	2	0	1	0	0
Endosulfan	5	3	2	1	1	1
Endrin [2,3]	2	1	1	0	0	1
Ethoprop	1	1	1	1	1	0

TABLE 3-4
Number of States in which each Pesticide has been Detected
(continued)

CHEMICAL	CATEGORY					
	1	2	3	4	5	6
Fonofos	2	2	2	2	2	0
Glyphosate	1	1	1	0	0	0
Heptachlor [3]	5	3	2	1	0	1
Hexazinone	2	2	1	1	1	0
Isofenphos	1	1	1	0	0	0
Lindane	8	6	5	3	3	1
Linuron	2	2	2	1	1	0
MCPA	2	2	1	1	0	0
Malathion	2	1	1	1	1	1
Metalaxyl	2	2	1	0	0	0
Methamidophos	1	1	1	1	1	0
Methomyl	2	2	2	1	1	0
Methyl parathion	3	2	2	1	1	1
Metolachlor	11	7	5	7	5	5
Metribuzin	6	6	5	6	5	1
Molinate	1	1	1	0	0	0
Naled	2	1	0	0	0	0
Oxamyl	3	3	3	3	3	0
PCNB	1	0	0	0	0	1
Paraquat	1	1	0	0	0	0
Parathion	1	1	1	1	1	0
Pentachlorophenol	4	3	1	2	0	1
Phosmet	1	1	1	0	0	0
Picloram	8	8	5	5	3	1
Prometon	2	2	2	1	1	0
Propachlor	2	2	1	1	0	0
Propazine	3	2	2	2	2	1
Silvex [3]	2	1	1	0	0	1
Simazine [1]	13	12	10	8	7	0
Sulprofos	1	1	1	1	1	0
TCP	1	1	1	0	0	0
TDE	1	1	1	1	1	0
Tebuthiuron	1	1	1	0	0	0
Terbufos	1	0	0	0	0	0
Toxaphene [3]	1	1	1	1	1	0
Triallate	1	0	1	0	0	1
Trifluralin	6	5	5	4	4	1

[1] CDFA 1987 confirmed, normal field use
[2] CDFA 1987 confirmed, point source or illegal use
[3] Pesticides which have been cancelled or their use has been severely restricted.

restricted.

Table 3-5 presents a summary for pesticides that have been detected in ground water due to normal agricultural use (category 5), point sources or misuse (category 6), and unidentified sources. This table only incorporates data that has been confirmed by the Agency to date. The table identifies which pesticides have been confirmed, the states in which they have been found, and their maximum and "median" concentrations in ground water. In this table, the median concentration is represented as the median of the average concentrations from each study included in the category (where the average concentration is calculated as the mean of all positive detections in a study). If a single study comprises the category, the median concentration is represented by the average concentration for the study. If the category is comprised of a single well, than the average concentration for that well is given. The table also indicates the proposed Health Advisory level for the pesticide, whether it has been included as an analyte in the Agency's National Pesticide Survey, and whether the pesticide has been cancelled or severely restricted. The results from categories 2 and 5 are depicted on a map of the United States in Figure 3-1.

3.3 Comparisons to Previous Assessments

Table 3-6 compares the results of these six categories to several other recent assessments of pesticides in ground water in the United States. The first study presented (EPA/OPTS, 1987) is an update to earlier assessments presented by the Agency in 1984 and 1986 (Cohen et. al, 1984; Cohen et. al, 1986) before the data base was formalized. The second study (Parsons and Witt, 1988) was conducted at Oregon State University, Department of Agricultural Chemistry and presents the results of a mail-in survey with lead state agencies. The third study was conducted by the U.S. Public Information Research Group (U.S. PIRG) in the summer of 1988 using EPA's public docket (Hind and Evans, 1988). The results from these three studies are presented on maps of the United States in Figures 3-2 through 3-4, respectively.

Discrepancies between the assessments are based on the data available to the researchers at the time of the study and the method used in their data

TABLE 3-5
Confirmed Pesticides Detected in Ground Water Due to Agricultural Use and Point-Source Contamination

Chemical Name	Cancelled or Severely Restricted	Analyte in NPS **	Health Advisory Level *** (ppb)	Normal Use (Category 5)			Point Source (Category 6)			Unknown Origin		
				States with Detections	Maximum Concen. (ppb)	Median Concen. **** (ppb)	States with Detections	Maximum Concen. (ppb)	Median Concen. **** (ppb)	States with Detections	Maximum Concen. (ppb)	Median Concen. **** (ppb)
1,2 D	Y	Y	0.0013 *	CA CT MA NY	550.00	4.50				CT HI	290.00	5.30
1,3 D		Y	0.20 *	NY	270.00	123.00	CA	N/A	N/A			
2,4,5 T	Y	Y	21				TX	2.99	2.85	KS MN	1.10	0.65
2,4 D		Y	70	CT MS	49.50	1.40	ID	36.50	0.91	KS MN	22.00	1.05
2,4 DB		Y					TX	0.23	0.23			
Alachlor		Y	1.5 *	CT FL IA IL KS LA MA MD ME NE PA WI	113.00	0.90	AR CA FL KS NE NY PA	99.90	1.80	KS MN PA	4.03	0.55
Aldicarb		Y	10	CA FL MA NC NY RI WI	315.00	9.00				MN	30.60	9.00
Aldrin		Y		MS SC	0.10	0.10						
Arsenic	Y			TX	N/A	N/A	TX	585.00	N/A	TX	100.00	15.30
Atraton		Y		MD	0.10	0.10						
Atrazine		Y	3.0	CA CO CT IA IL KS MD ME NE NJ PA VT WI	40.00	0.50	AR KS NE NY PA VT WI	1500.00	4.35	KS NE PA TX	107.20	2.35
BHC	Y	Y		MS	4.30	2.70	ID	0.02	0.02			
Bromacil		Y	80	CA FL	22.00	9.00	KS	5.50	2.80	KS	17.00	2.80
Carbofuran		Y	36	MA NY RI	176.00	5.30						
Chlordane	Y	Y	0.03 *	MS	1.80	1.70	ID	0.04	0.04	KS	7.90	0.53
Chlorothalonil		Y	1.5 *	ME NY	12.60	0.02	CA	N/A	N/A			
Cyanazine		Y	9.0	IA LA MD NE PA VT	7.00	0.40	NY	1.00	1.00	MN	2.90	0.51
DBCP	Y	Y	0.02 *	CA AZ	0.02	0.01				SC	1.00	N/A
DDT	Y	Y		MS NJ SC	402.00	1.70	ID	0.76	0.02			
Dacthal		Y	3500	NY	1039.00	109.00						
Diazinon		Y	0.63	MS	478.00	162.00	CA	N/A	N/A			
Dicamba		Y	9.0	CT ME	1.10	0.60	ID	0.49	0.02	MN TX	0.88	0.66
Dieldrin	Y	Y	0.00219 *	ME NJ	0.02	0.02	ID	0.09	0.01	KS	0.26	0.18
Dinoseb	Y	Y	7.0	MA ME NY	36.70	0.70						
Diuron		Y	14	CA	N/A	N/A						
EDB	Y	Y	0.0005 *	CA CT GA MA NY WA	14.00	0.90	WA	5.70	0.82			
Endosulfan		Y		ME	0.40	0.30	KS	0.06	0.04			
Endrin	Y	Y	0.032				CA	N/A	N/A			
Ethoprop		Y		NY	12.60	N/A						
Fonofos			14	IA ME	0.90	0.10						
Heptachlor	Y	Y	0.076 *				ID	0.02	0.02	KS	0.03	0.03
Hexazinone		Y	210	ME	9.00	8.00						

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TABLE 3-5
Confirmed Pesticides Detected in Ground Water Due to Agricultural Use and Point-Source Contamination (continued)

Chemical Name	Cancelled or Severely Restricted	Analyte in NPS **	Health Advisory Level *** (ppb)	Normal Use (Category 5)			Point Source (Category 6)			Unknown Origin		
				States with Detections	Maximum Concen (ppb)	Median Concen **** (ppb)	States with Detections	Maximum Concen (ppb)	Median Concen **** (ppb)	States with Detections	Maximum Concen (ppb)	Median Concen **** (ppb)
Lindane	Y	Y	0.026 *	MS NJ SC	47.00	0.10	ID	0.08	0.08			
Linuron		Y		WI	2.70	1.90						
Malathion				MS	53.00	41.50	ID	5.20	0.03			
MEPA										MN	2.20	0.26
Methamidophos				ME	10.50	4.80						
Methomyl		Y	175	NY	9.00	N/A						
Methyl parathion		Y	2.0	MS	256.00	88.40	ID	0.01	0.01			
Metolachlor		Y	10	CT IA IL PA WI	32.30	0.40	AR KS NY TX VT	112.00	4.60	KS MN PA	48.00	0.61
Metribuzin		Y	175	IA IL KS WI	6.80	0.60	KS	2.10	1.14	KS MN	1.05	0.23
Oxamyl		Y	175	MA NY RI	395.00	4.30						
PCNB							ID	0.22	0.02			
PCP		Y	220				ID	0.05	0.01	MN MS	149.00	9.44
Parathion				ND	0.04	0.03						
Picloram		Y	490	ME ND WI	49.00	1.40	ND	3.56	0.40	KS MN ND	12.80	3.40
Prometon		Y	100	TX	29.60	16.60						
Propachlor										MN	0.50	0.35
Propazine		Y	14	ME PA	0.20	0.20	KS	2.50	N/A			
Silvex	Y	Y	52				ID	0.62	0.01			
Simazine		Y	35	CA CT MD NE NJ PA VT	9.10	0.30				MN PA	3.40	0.72
Sulprofos				IA	1.40	1.40						
TDE	Y	Y	0.031	MS	6.20	4.80						
Toxaphene	Y			MS	4910.00	3205.00						
Trialiate							ID	0.13	0.01			
Trifluralin		Y	2.0	KS MD MS NE	2.20	0.40	ND	0.03	0.03	KS	5.40	3.09

* Lifetime exposure levels based on a 10^{-6} risk of causing cancer.

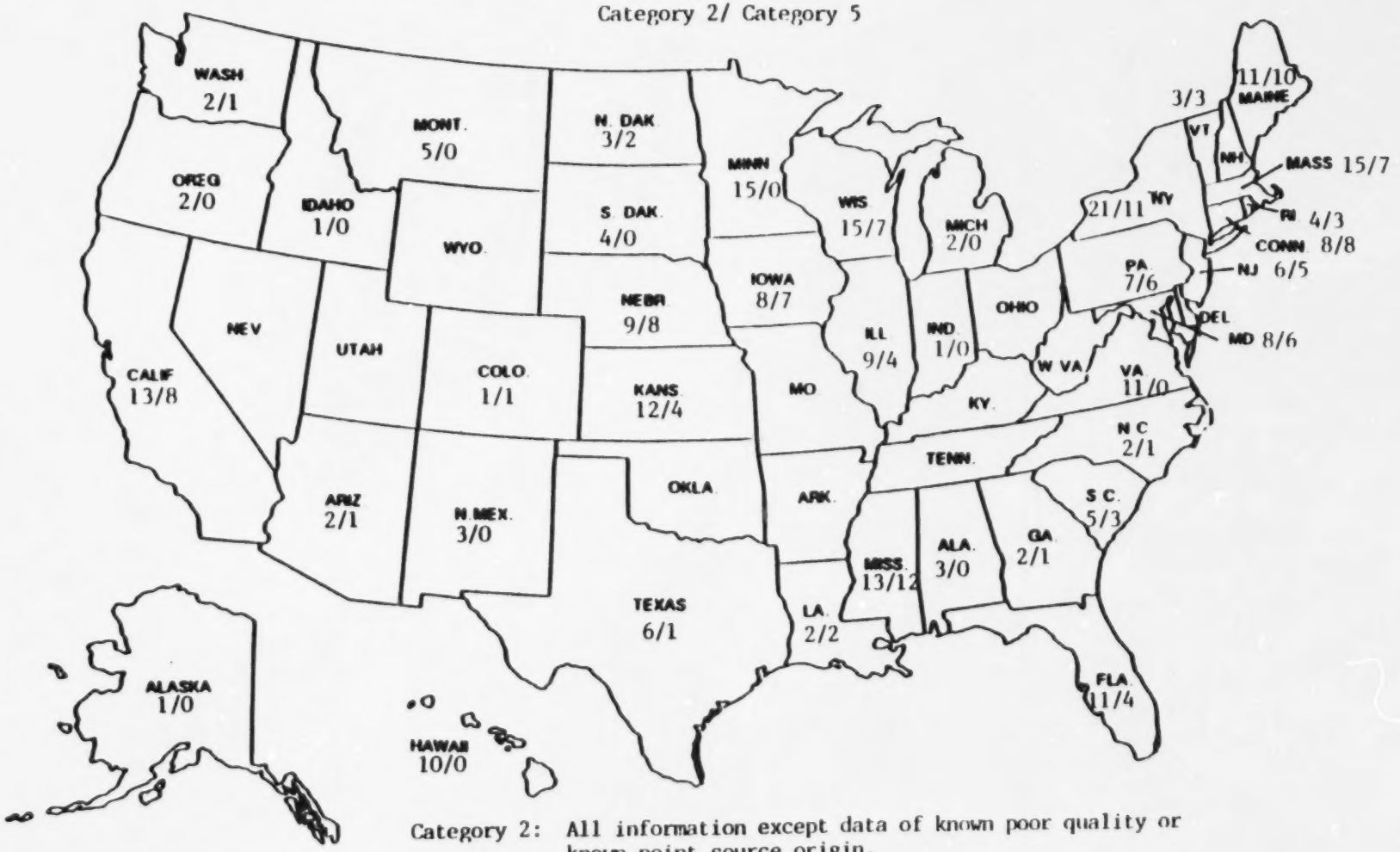
** National Pesticide Survey

*** Proposed Lifetime Health Advisory Level

**** Median of the concentration of positive detections for all confirmed studies. If a particular chemical does not list multiple studies, then the single study average is given. If the data base reports a single positive well, than the average concentration reported for that well is given

FIGURE 3-1

Numbers of Pesticides Found in Ground Water As a Result of Agricultural Practice



Category 2: All information except data of known poor quality or known point source origin.

Category 5: Only confirmed data attributed to agricultural uses.

TABLE 3-6
National Assessments of Pesticides in Ground Water:
Current vs Prior

PRIOR ASSESSMENTS

Source	No. of Pesticides Detected	No. of States with Detected Pesticides
EPA/OPTS (1987)	19	24
Parsons & Witt (1988)	67	33
U. S. PIRG (1988)	73	34

CURRENT ASSESSMENTS

Category	Description	No. of Pesticides Detected	No. of States with Detected Pesticides
1	All data	77	39
2	All data except suspected point sources or known poor quality.	74	38
3	Suspected field use data excluding known poor quality.	65	36
4	Confirmed, quality data of unknown or suspected field use origin.	52	27
5	Confirmed, quality data of known or suspected field use origin.	46	26
6	Confirmed, quality data of known or suspected point source origin.	32	12

FIGURE 3-2

Numbers of Pesticides Found in Ground Water As a Result of Agricultural Practice

(U.S. EPA/OPTS, 1987)

FIGURE 3-3

Numbers of Pesticides Found in Ground Water

(Parsons & Witt, 1988)

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FIGURE 3-4

Numbers of Pesticides Found in Ground Water As a Result of Agricultural Practice

(U.S. PIRG, 1988)

collection and interpretation. The assessment by the Agency shown in Figure 3-2 (EPA/OPTS, 1987) was based on a much smaller data base than the Agency currently has and incorporated a less formal system for confirming the data then is presently being used by the Agency. It is important to note that the 1987 assessment reveals data from states that are not currently in category 5. This information will most likely be incorporated into category 5 once the formal data confirmations are complete.

Differences between the current assessment (Figure 3-1) and that of Parsons and Witt (Figure 3-3) are primarily based on how the data was collected. Parsons and Witt based their study on a mail-in survey with lead state agencies. EPA's current assessment has endeavored to obtain data from additional agencies and sources, differentiate the data based on origin of contamination, and collect additional background information on the studies and the analytical technique used to quantify results. The report by Parsons and Witt has not been formally released at the time of this writing.

U.S. PIRG produced their report in September of 1988 using data from the public docket. During this time, EPA has acquired additional monitoring results and confirmations on many of the studies. Some of the data used by U.S. PIRG has been superceded by updated reports. Some of the detections credited as being caused by normal agricultural use have been verified as point-source contamination or the results of nonpesticidal use of chemicals. The report was generated in a short time frame and as a result, some chemicals have been counted twice and are represented by trade names as well as by their common names.

3.4 About the Appendices

The appendices include additional information on the data base. Appendix A outlines the structure and data elements and discusses the confirmation program. Appendix A also provides guidance on interpreting the tables in the subsequent appendices.

Appendices B and C can be used to identify the pesticides or states for each assessment category in Tables 3-1 through 3-6. Details on the detections

can also be obtained here. Appendix B lists positive detections sorted by chemical and then by state. Appendix C presents the same data sorted by state and then by chemical. For each monitoring study reporting detections in ground water, these appendices present: (a) the suspected or known source of contamination, (b) the number of wells tested for each pesticide, (c) the number of positive wells found, (d) the number of samples taken, (e) the number of positive samples, (f) the range of concentrations of the positives, (g) the average of all positive concentrations, and (h) the confirmation rating assigned to the results. To the extent possible, the data in a study has been itemized by origin of contamination and has been segregated down to the county level.

Appendix D summarizes all data in the data base by chemical including studies for which no detections were noted. For each assessment category, the appendix includes: (a) total number of wells sampled, (b) the total number of positive wells, (c) the total number of samples taken, (d) the total number of positive samples, (e) the total number of states in which the chemical was sampled, (f) the number of states having positive detections, (g) the range of concentrations of all positive detections, and (h) the range of the average concentrations of the positives from the individual studies.

It is important to note that this data reflects an automated sort by computer, and as such certain anomalies in the parameters may require explanation. For example, if a particular author has presented his results by wells and not by samples, the study would not contribute to the sample totals presented in the appendix. As such, it is conceivable that the tables could present a larger number of wells than samples. Also, the tables only reflect totals for studies that are identified as belonging to each respective assessment category and the statistical population may not be accurately represented. For example, relating the number of positive wells for a chemical to the total number of wells sampled can be misleading. Therefore, each value in the appendix is not conclusive in itself and it is important that the appendix is used cautiously with this knowledge in mind.

Appendix E contains the bibliography for the studies in the data base. Comments relative to the studies and/or confirmation process are also included

here. Appendix F presents the full listing for each study in the data base and is under separate cover.

It should be noted that each study in the data base is referenced by a five character identification code (e.g., "VT001" for Vermont study 001). This code can be used to track each study given in Appendices B and C. This code can be used to obtain the formal reference for the study from Appendix E and the full data base listing of the study from Appendix F. This code is also compatible with the filing system used in the public access docket.

4.0 CONCLUSIONS

4.1 Caveats on Using the Data Base

Agricultural pesticides have been found in domestic drinking water wells at levels of toxicological concern. Ground-water contamination caused by pesticides can be the result of many factors including: the physicochemical characteristics of the pesticide, frequency and rates of application, the hydrogeologic setting in which the chemical is used, the climatology of its use environment, and other agronomic practices.

Pinpointing the source of pesticide contamination is perhaps the most difficult parameter to confirm in the data base. Contamination can result from causes other than leaching due to normal field applications. These causes include: pesticide disposal, accidental spills, rinsate from equipment maintenance, human error in dilution, intentional excess applications, back siphoning into a well during chemigation, or direct channelling of pesticides through poorly constructed or damaged wells. It is difficult to conclude with confidence that an incident of ground-water contamination is attributed to leaching from normal agricultural use, unless the use histories near the site are known, and point sources are ruled out.

There are dangers in trying to use the data base to indicate the statistical significance of the problem on a national level. Most significantly is the fact that many agricultural areas have not been sampled and are not statistically represented in the data. In addition, data confirmations are not complete and many origins of contamination are unknown.

It is important to note that the studies in the data base have not been conducted and reported under a single standard protocol. The studies were designed and conducted by many different agencies for different purposes. Many of the studies were only designed to sample vulnerable ground water or to investigate suspected problems, while other studies were designed to be statistically unbiased. It is important to note that the studies have not been limited to drinking water supplies and the studies have sampled many types of wells including wells used only for observation or irrigation. Many

of the studies have concentrated on shallow ground water which may not be representative of the drinking water sources of the area. Many of the detections represent one sampling point in time which cannot measure the persistence of a problem. As such, the results cannot be used to estimate human exposure to pesticides in drinking water from a national perspective.

Because the studies were not conducted and reported with the data base in mind, many of the data base elements have not been reported in the source documents. Many but not all of these data holes are being resolved through the data confirmation program. However, assessments made from the data base can be difficult or inconclusive. Statistics from the data base must be used carefully and with caution. For example, statistically derived parameters based on the positives attributed to normal field use are suspect if the origin of the majority of positives are not known. Similarly, the ratio of the number of well positives to the number of wells sampled cannot be determined reasonably if certain references include information on positives, but none on nondetections. Biases in the design of studies, and where they have been conducted to date, also influence statistical assessments.

For these reasons, derived parameters contained in the report and in the appendices should be treated as indicators rather than absolute values.

4.2 Major Data Gaps

There are approximately 130 reports entered in the data base (representing approximately 150 different monitoring studies). To date, 50 percent of these reports have been confirmed, and roughly 20 percent of all entries have unknown origins. This accounts for the range in values in categories 2 and 5. To date, nearly 70 percent of the reports incorporated into the data base by April 1988 have been confirmed.

Difficulties exist in undertaking this kind of a confirmation program. The Agency is at the mercy of the schedules, cooperation, and ability of each study director to confirm their results. Some studies cannot be confirmed because details on the study are not retained in records. Particular states for which significant data confirmations are pending include: Florida,

Hawaii, Minnesota, New York, Virginia, and Wisconsin. Additional data gaps include the following:

- USGS observations wells. USGS routinely monitors for select pesticides in their ground-water quality monitoring network. These results are maintained in the Survey's WATSTORE data base and periodically transferred to EPA's STORET data base. The Survey adheres to a quality control program on data entered into WATSTORE. This data has not been given the highest priority in EPA's Pesticides in Ground Water Data Base primarily because the origin of contamination for detections are difficult to assess.

- Aldicarb. The confirmation for many of the aldicarb monitoring programs has not been completed. Many monitoring studies have been conducted for aldicarb in ground water from the late 1970's until the present and the volume of this data is overwhelming. This data accounts for several of the locations where pesticides have been detected in Figure 3-2 but not in category 5 of Figure 3-1.

  Rhone-Poulenc Ag. Company maintains a computerized data base on ground-water monitoring results from studies that they have conducted. Their studies have been limited to drinking water sources and the origin of positive detections have generally been attributed to nonpoint sources. We are coordinating Rhone-Poulenc to verify that the Agency's data is comprehensive and confirmed.

- Atrazine. Ciba-Geigy Corporation has developed a data base containing monitoring for atrazine in ground water. Their data base is attributing roughly 75 and 90 percent of detections of atrazine in ground water in the United States and Canada, respectively, to point-source origins. Ciba-Geigy is cooperating with the Agency to resolve discrepancies between both data bases.

- California. The California Department of Food and Agriculture (CDFA) has developed an excellent statewide well inventory and data base on pesticides in ground water. EPA is using this data base as the principal source for data in California. While their computer data base has not been fully merged into EPA's data base, the results presented herein have been obtained from published reports (Brown, et.al, 1986; Ames, et.al, 1987). Chemical names and information on the number of positive wells and samples have been obtained from the 1986 report, however, details on the concentrations were not documented in the report. Confirmed data attributed to agricultural and point source origins have been obtained from the 1987 report. Since many of the same wells sampled and reported in the 1987 update had been reported but not distinguished in the 1986 report, the 1987 data has not been entered into EPA's data base in order to avoid duplicating wells. Concentrations and total well counts will be obtained directly from CDFA's computer data base and incorporated into EPA's data base in the future.

4.3 Discussion on the Results

From the data received to date, the precise representation of pesticide residues in ground water, as a result of normal agricultural application, is probably greater than category 5. This is because many of the studies have yet to be confirmed and many of the unknown sources may have been caused by normal agricultural practices. In addition, many agricultural areas have not been sampled. Given the right conditions, nearly every chemical has the potential to leach to ground water. However, it is important to note that one or two detections of a pesticide at trace levels may not in and of themselves indicate a problem. But, a pesticide detected at numerous locations at concentrations equal to or greater than Health Advisory levels is reason for concern and further investigation. Therefore, it is critical to look at both the frequency of detections and their concentrations, and how those concentrations compare to established and proposed health numbers for a specific pesticide.

Table 3-5 illustrates that from normal use, 18 pesticides have been confirmed in ground water at levels equal to or above established or proposed Health Advisory levels. It is important to note that all of these pesticides are on the list of analytes being screened as part of the Agency's National Pesticide Survey.

From Table 3-6, it would appear that an increasing number of pesticides are contaminating ground water. However, Table 3-6 is better explained by the fact that more people are looking for pesticides in ground water and these results reflect increased monitoring efforts. Awareness of the issue has led to voluntary and mandatory restrictions of many of the more toxic, persistent, and mobile chemicals, such as DDT an DBCP. As illustrated in Table 3-5, seven of the pesticides having detections in excess of Health Advisory levels have either been cancelled or have had their use severely restricted.

4.4 Future Uses of the Data by EPA

The data base will be used by the Agency as a tool to supplement the pesticide registration process. It is currently being used to target

pesticides that are contaminating ground water inorder to establish priority candidates for regulation to mitigate such problems. The data base is being used to help pinpoint the migration pathways and environmental factors associated with contamination which are the first steps in developing mitigation strategies. By overlaying pesticide monitoring results with pesticide use data and hydrogeoglogic factors, it will be possible to highlight vulnerable areas that are candidates for reduced or altered application and to depict data gaps where additional monitoring should be conducted. In addition, the data base can be used in support of the reregistration of a pesticide for which ground-water contamination has not been shown to be a problem.

The importance given to the data base to supplement the regulatory process will increase as the data base evolves. The data base is in a dynamic state of development; confirmations on the data presently entered in the data base continue and additional monitoring studies are received periodically. Many states and pesticide registrants have ongoing ground-water monitoring programs and other states and registrants are either implementing or expanding monitoring efforts. These studies will provide additional information on the sources and impacts of pesticide residues in ground water. The results and conclusions contained herein are interim and will be updated as further information is collected and processed.

5.0 REFERENCES

Ames, M., C. Cardozo, S. Nicosia, J. Troiano, S. Monk, S. Auli, and S. Brown, "Sampling for Pesticide Residues in California Well Water: 1987 Update, Well Inventory Data Base", Second Annual Report to the Legislature, State Department of Health Services, and State Water Resources Control Board, State of California, Department of Food and Agriculture, Division of Pesticide Management, December 1, 1987.

Brown M., C. Cardozo, S. Nicosia, J. Troiano, and S. Ali, "Sampling for Pesticide Residues in California Well Water: 1986 Well Inventory Data Base", First Annual Report to the Legislature, State Department of Health Services, and State Water Resources Control Board, State of California, Department of Food and Agriculture, Division of Pesticide Management, December 1, 1986.

Cohen, S.Z., C. Eiden, and M.N. Lorber, "Monitoring Ground Water for Pesticides", in Evaluation of Pesticides in Ground Water, ACS Symposium Series #315, W.Y. Garner, R.C. Honeycutt, and H.N. Nigg, ed., American Chemical Society, Washington, D.C., 1986.

Cohen, S.Z., S.M. Creeger, R.F. Carsel, and C.G. Enfiel, "Potential for Pesticide Contamination of Groundwater from Agricultural Uses" in Treatment and Disposal of Pesticide Wastes, ACS Symposium Series #259, R.F. Krueger and J.N. Seiber, ed., American Chemical Society, Washington, D.C., 1984.

Farm Chemicals Handbook, Meister Publishing Co., Willoughby Ohio, 1987.

Hind, Rick and Eliza Evans, "Pesticides in Ground Water: EPA Files Reveal Tip of Deadly Iceberg", U.S. Public Interest Research Group, September, 1988.

Holden, Patrick W., Pesticides and Groundwater Quality: Issues and Problems in Four States, National Academy Press, Washington, D.C., 1986.

Parsons, Douglas W. and James M. Witt, "Pesticides in Groundwater in the United States of America: A Report of a 1988 Survey of State Lead Agencies", Oregon State University, Department of Agricultural Chemistry, Corvallis Oregon, June 15, 1988 (Draft).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances, "Agricultural Chemicals in Ground Water: Proposed Pesticide Strategy", Washington, D.C., December 1987.